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Diversity and Potency of *Capsicum* spp. Grown in Indonesia

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Abstract

Capsicum spp., popularly known as chili pepper, is abundantly cultivated in Indonesia. Chili pepper has deeply integrated into Indonesian culture, even turned into inseparable ingredients in the local diets. Adapted to the Indonesian environment and timely selected according to the local palate, vast variation of appearance, color, taste, aroma, and pungency of chili pepper transformed into a variety of cuisines and medicinal purposes. This chapter covers a selection of chili peppers in Indonesia, introduced as “commonly available in the market,” and some other variants, which are less popular; however, due to their unique flavors, they will be interesting to be introduced and addressed as “exotic *Capsicums*.” This chapter will describe their botanical information, distribution area, and nutritional and flavor aspects, including their bioactive compounds. Furthermore, the utilization of genus *Capsicum* in Indonesia, from the food industry, pharmaceutical, and ornamental plants, will be described.

Keywords: bioactivity, *Capsicum* spp., chili pepper, flavor, Indonesia

1. Introduction

Portuguese brought *Capsicums* to the eastern part of Indonesia, Maluku, in the seventeenth century and then widely distributed to other parts of the archipelago. It is assumed that the four species (*C. annuum*, *C. frutescens*, *C. chinense*, and *C. pubescens*) were introduced to Indonesia before World War II [1]. During that time, the Javanese called the plant “godong sabrang,” which means a plant from a foreign country [2]. Later, in each region of Indonesia, *Capsicums*, especially chili or hot peppers might have different names, like “cegek,” “lado,” “lada,” “cabe,” “cabi,” “lombok,” “ricagufu,” “serbeh ulom,” “serbeh,” and many others. However, officially, pungent members of *Capsicums* or hot chili peppers in Indonesia are called “cabai,” while the sweet and nonpungent ones are called “paprika.” From then on, in this text, we use the term “cabai” for hot peppers or chili peppers and “paprika” for sweet peppers.

The *Capsicums* currently cultivated in Indonesia are quite different from those first carried by the Europeans since they have been crossbred and undergone genetic changes due to adaptation to local environments and natural and human selection. The seeds of *Capsicums* cultivated in Indonesia are also distributed to neighboring countries and even to Macau, China [3, 4]. During that time, local inhabitants of Java Island used *Capsicum* fruits in their cooking, while the leaves were used for topical ointment.

Indonesia also included *Capsicums* as part of their traditional ceremony and ritual. In some ceremonies in Java, sometimes, they put *Capsicums* on top of *tumpang*, a traditional dish consisting of cone-shaped yellow-colored rice complemented

with other side dishes and vegetables. Examples of traditional Indonesian dishes using *Capsicums* are *sambal terasi* (Java), *balado Padang* (West Sumatra), *rica-rica Manado* (North Sumatra), and *lawar* (Bali). *Lawar* from Bali was involved in wedding, death, and other religious ceremonies [2].

Capsicum has become an essential commodity in Indonesia, where its price might influence political and socioeconomic conditions. Similar to what happened in South Korea in 1978–1979, where the people’s unrest was subjected to the government due to a shortage of *Capsicums* [5], in Indonesia, the price of *cabai* could be one of the parameters to measure the government performance in establishing food security. For the majority of Indonesians, regardless of social class or economic status, *Capsicum* has become an inseparable part of their daily consumption and may serve as a source of vitamin C, E, and folate, as well as carotenoids, phenolic compounds, flavonoids, and capsaicinoids [6, 7]. Even with the decrease in household incomes or an increase in household expenses, consumers still tend to buy *cabai* [8, 9]. Like India, Thailand, and South Korea [5, 10], the consumption of *Capsicums* in Indonesia was also high. Among other vegetable plantations, *cabai* occupied 416,3981 ha of cultivation area in 2019 [11], the second largest in the country after cabbage.

Cabai prices could influence the price of other food products, affecting the economy, consumption, and buying habits of the consumers. Hence, the fluctuation of *cabai* prices could trigger inflation. For example, in the rainy season, there is a possibility of decrease in *cabai* production due to the crop failure. The unmet high demand, causing a double increase in price for *cabai*, resulted in inflation. This phenomenon has already occurred for several years. *Cabai* contributed 0.09% of 0.28% Indonesian inflation level in the early rainy season in October 2018, and *cabai* was also reported as the leading cause of Indonesian economic inflation in 2006 based on data from Statistics Indonesia [13].

2. Types of *Capsicum* species in Indonesia

From the genus *Capsicum*, there are 27 species members, including five domesticated species (*C. annuum*, *C. frutescens*, *C. chinense*, *C. pubescens*, and *C. baccatum*) around the globe [14]. *Capsicum* species commercially cultivated in Indonesia are *C. annuum* and *C. frutescens* as seen in **Figure 1**. The other species like *C. chinense* and *C. pubescens* can only be found in several districts and usually cultivated by



Figure 1.
Capsicums commonly available in Indonesian market.

hobbyists [4]. From the distribution of *C. chinense* in Indonesia, though it is very limited in Southeast Asia, it is assumed that “Indonesia had more potential and genetic resources to breed species of *Capsicum* than other countries in Southeast Asia” [1].

In Indonesia, there are *Capsicum* hybrid lines produced by seed agents, like “cabai sultan,” “hot beauty,” “megahot,” “Carvi Agrihorti,” and “cabai trisula.” *Capsicum* hybrid lines were most farmer’s favorites, due to their high productivity beside their relatively high prices. However, as progenitors, they might not be good candidates due to their variability in the progenies. Meanwhile, the local and open-pollinated cultivars might not produce as much yield as hybrid lines, but they are generally more resistant to pests and disease, cheaper, and fit to use as progenitors [15]. The cultivated variety is selected based on market demand (color, aroma, taste, pungency, appearance, and size), high productivity, resistance to pests and disease, and adaptability to the local environment. Meanwhile, the consideration in choosing seeds is the availability of the seed’s certificate, moisture content, seed purity, germination, absence of contaminants, and seed’s health.

2.1 Commonly available in the market

2.1.1 Cabai keriting (*Capsicum annuum* L. var. *Longum*)

Cabai keriting is a highly marketable commodity. The fruits are thin-skinned, long (around 12 cm), slender, curly, or wavy in appearance with pointed tips as shown in **Figure 2** [16]. There are many seeds inside the fruit. The plants usually have a productive age up to 6 months in relatively high humidity with a temperature around 16–32°C, soil pH around 5–7 [17], and relatively resistant to plant diseases and can be harvested all year round [4]. On average, each plant can produce up to 0.75–1 kg fruit/harvesting period, i.e., 6 months. The fruits are harvested both in the immature stage (green) and the mature stage (red) [18].

This cultivar of *Capsicum* is one of the superior and popular cultivars in Indonesia due to the plants’ productivity and relatively high price, and their thin skin and lower moisture than *cabai merah besar* make them not so prone to rot and have longer shelf-life compared to *cabai merah besar* [4, 17]. Some known varieties are *cabai keriting Solok*, *cabai keriting Cirebon*, *cabai keriting Irian*, *cabai keriting ungu*, *cabai keriting Lampung*, *cabai keriting Padang*, *cabai keriting Bengkulu*, *cabai*



Figure 2.
Cabai keriting (*C. annuum* L. var. *Longum*).

keriting Lembang, *cabai keriting Pangalengan*, and *cabai keriting Medan* [19, 20]. In 2011, there were 86 cultivars of *cabai keriting* in total [21]. From the plant morphology, there were 13 parameters to consider in choosing cultivars, i.e., leaf shape, leaf tip, the color of the anther, the color of pistil, fruit surface, the color of young fruit, plant height, dichotomous height, canopy width, fruit length, fruit diameter, and fruit weight [15]. Examples of popular *cabai keriting* seeds cultivated in Indonesia are Taro, Lado, Bagayo, Tanamo, Jago, New Taro, and Laris. A picture of *Cabai keriting* grown in Indonesia is shown in **Figure 2**.

Distribution areas. *Cabai keriting* is usually cultivated in West Java and Sumatra Island (Bengkulu, Lampung, West Sumatra, and North Sumatra) [16, 19].

Flavor characteristics. The taste of *cabai keriting* is relatively hotter than *cabai merah besar* (*C. annuum*) but not as hot as *cabai rawit* (*C. frutescens*). There were several varieties of *cabai keriting* in Indonesia, e.g., *cabai keriting ungu*, *cabai keriting Lampung*, *cabai keriting Padang*, *cabai keriting Bengkulu*, *cabai keriting Lembang*, *cabai keriting Pangalengan*, and *cabai keriting Medan*, according to the order of their pungency from low to high with Scoville heat unit (SHU) varied from 30,000 to 170,000 [19]. Since the flavor components change during maturation [22], it would be important to notice that the green and red maturing stage of *cabai keriting* might alter the character of the dishes. For example, *ayam cabe hijau* was a traditional cuisine that is uniquely characterized by the use of immature stage (green) of *cabai keriting* as the main seasoning for cooked chicken. Meanwhile, red *cabai keriting* is usually used in cooking for its attractive red color and relatively hot pungency.

Bioactivity and health benefits. *Cabai keriting* was believed to have antimicrobial effects; thus, the inhibitory effect of the oleoresin of *cabai keriting* against *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Escherichia coli*, and *Pseudomonas aeruginosa* had been reported [23]. The oleoresin contained tetramethyl hexadecanol, tetramethyl hexadecene, tetramethyl hexadecapentaene, ethyl decahexanoate, ethyl linoleate, methyl linoleate, palmitoyl chloride, hexanedioic acid, octadecadienoic acid, ethyl linoleolate, butyl isopropylphenyl oxalate, and capsaicin.

2.1.2 *Cabai merah besar* (*Capsicum annuum* L.) and (*Capsicum annuum* L. var. *Tanjung*)

The fruits of *cabai merah besar* are quite long, big, and bulky with a smooth surface and thick skin [12]. Some fruits have sharp points, and the others have round points [24]. On average, each plant can produce up to 1–1.2 kg fruit/harvesting period [18], but this number depends on the varieties, agricultural practices, and plants' environments. The farmers harvest both immature fruits (green) and mature fruits (red) of *cabai merah besar*.

Some known varieties of *cabai merah besar* are Ciko, Lingga, Tanjung, Kencana, Tit Super, Paris, and Jati Laba. In 2011, there were 87 cultivars of *cabai merah besar* in total [21]. Examples of popular *cabai merah besar* seeds cultivated in Indonesia are Profit, Arimbi, Horison, Imperial 10, Jet Set, Imola, Gadewa, Gada, Elegance, and Gada MK. *Cabai merah besar* is shown in **Figure 3**.

Distribution areas. *Cabai merah besar* is cultivated in almost every province in Indonesia especially in West Java, Central Java, North Sumatra, East Java, West Sumatra, Aceh, Lampung, South Sumatra, South Sulawesi, and Bengkulu [25].

Flavor characteristics. There were several varieties of *cabai merah besar* in Indonesia, e.g., Tit Super, Paris, and Jati Laba, with pungency around 12,500 SHU [19]. *Cabai merah besar* is the least hot compared to *cabai keriting* and *cabai rawit* (*C. frutescens*). The popular cultivar of *C. annuum* was less hot compared to *C. frutescens* [26]. Since their pungency is considered low, *cabai merah besar* is usually used due to its attractive color, texture, and aroma, not because of their pungency.



Figure 3.
Cabe merah besar (*C. annuum* L.) in the market.

The fruits have a crunchy texture and higher moisture content compared to *cabai keriting*. However, the same with *cabai keriting*, both green and red maturing stages of *cabai merah besar* are also used, but the application is different depending on the intended dishes. The green stage of *cabai merah besar* is usually boiled, stir-fried, or fried before consuming, to remove unwanted aroma.

Nutrition component. *Cabai merah besar* contains moisture (90%), energy (32 kcal), protein (0.5 g), fat (0.3 g), carbohydrate (7.8 g), fiber (1.6 g), ash (0.5 g), calcium (29.0 mg), phosphorus (45 mg), iron (0.5 mg), vitamin A (470 IU), vitamin C (181 mg), thiamin (0.05 mg), riboflavin (0.06 mg), and niacin (0.9 mg) per 100 g red fruits [27–29], while the green fruits contain energy (23 kcal), protein (0.7 g), fat (0.3 g), carbohydrate (5.2 g), calcium (14 mg), phosphorus (23 mg), iron (0.5 mg), vitamin A (260 IU), and vitamin C (84 mg) per 100 g fruits [24].

Bioactivity and health benefits. It is reported that the ethanolic extract of *cabai merah* with a dosage of 200, 400, and 600 mg/kg was effective in lowering blood sugar levels in male white mice hyperglycemia [30]. The most effective duration in lowering blood glucose levels was 21 days. The possibility of luteolin extracted from *C. annuum* L. as an alternative to treat autism spectrum disorder (ASD) using the reverse docking technique has been explored; the result showed that luteolin had a potency to work as an MMP-3 antagonist. MMP-3 (matrix metalloproteinase) was suspected of having a role in the neuropathology of ASD [31].

A study about *cabai merah* effects towards hypercholesterolemia showed that 200 mg/kg ethanolic extract of *cabai merah* had a cholesterol-lowering effect on hypercholesterolemia mice with the best administration duration in lowering blood cholesterol of male albino mice of 14 days [32]. The conversion of this dose to humans with the average body weight of 70 kg results in as much as 173.15 g of *cabai merah* needed to get the expected effect. This bioactivity might be attributed to several compounds such as capsaicin, vitamin C, saponin, and flavonoid compounds. It is reported that dietary capsaicin improved endothelium-dependent vasorelaxation and prevented hypertension [33].

The inhibitory effect of oleoresin of *cabai merah besar* against *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Escherichia coli*, and *Pseudomonas aeruginosa* was also reported. Oleoresin contained tetramethyl hexadecenol, tetramethyl hexadecene, tetramethyl hexadecapentaene, ethyl hexadecanoate, linoleic acid, methyl linoleate, azacylotridecanone, hexanedioic acid, octadecadienoic acid, ethyl linoleolate, octadecenyl acetate, and capsaicin [23].

2.1.3 Paprika (*Capsicum annuum* var. *grossum*)

The fruit color and shape vary as shown in **Figure 4**, but mostly they have bell-shaped, long with pointed tips or almost square with hollow space inside, and thick skin (around 0.5 cm). The fruit is relatively big compared to *cabai merah besar* [12, 34]. The seeds are clustered together and attached to the placenta [35]. On average, each plant can produce around 3.5–3.7 kg fruit/harvesting period, i.e., 12 months [18]. There are many paprika seed varieties cultivated in Indonesia, for example, Jumbo seed, Takii ace, Green Horn, New Ace, Wonder Bell, Top Star, Blue Star, Uranus, Big Star, Queen Star, Beauty Bell, Sunny Star, Lucky Star, Colombo, Mayata, Golden California Wonder, Skipper, Melody, Fortuna, Yellow Star, and Virgo [35].

Distribution areas. Paprika is usually cultivated in North Sumatra, Riau, West Java, East Java, Bali, West Nusa Tenggara, East Nusa Tenggara, Central Sulawesi, Southeast Sulawesi, Maluku, and West Papua [25].

Flavor characteristics. The fruit tastes mildly sweet with a crunchy texture. The fruit aroma has a pungent impression but does not taste hot at all [34]. The fruit slices are usually cooked with meat or as pizza toppings.

Nutrition components. The fruit contains protein 0.9%, fat 0.3%, carbohydrate 4.4%, calcium 7 mg/100 g, phosphorus 22 mg/100 g, iron 0.4 mg/100 g, vitamin A 22 IU/100 mg, vitamin B1 540 mg/100 g, vitamin B2 0.02 mg/100 g, vitamin C, 160 mg, and niacin 0.4 mg/100 g [35].

Bioactivity and health benefits. As an herbal medicine, consuming paprika is suggested to control cholesterol and triglycerides and prevent atherosclerosis, hypertension, flu, sinusitis, and digestion problem [36]. One study found that the ethanolic extract of paprika exhibited antimicrobial activity towards pathogen *Enterococcus faecalis* [37]. Another study reported that *Capsicum annuum* var. *grossum* could be

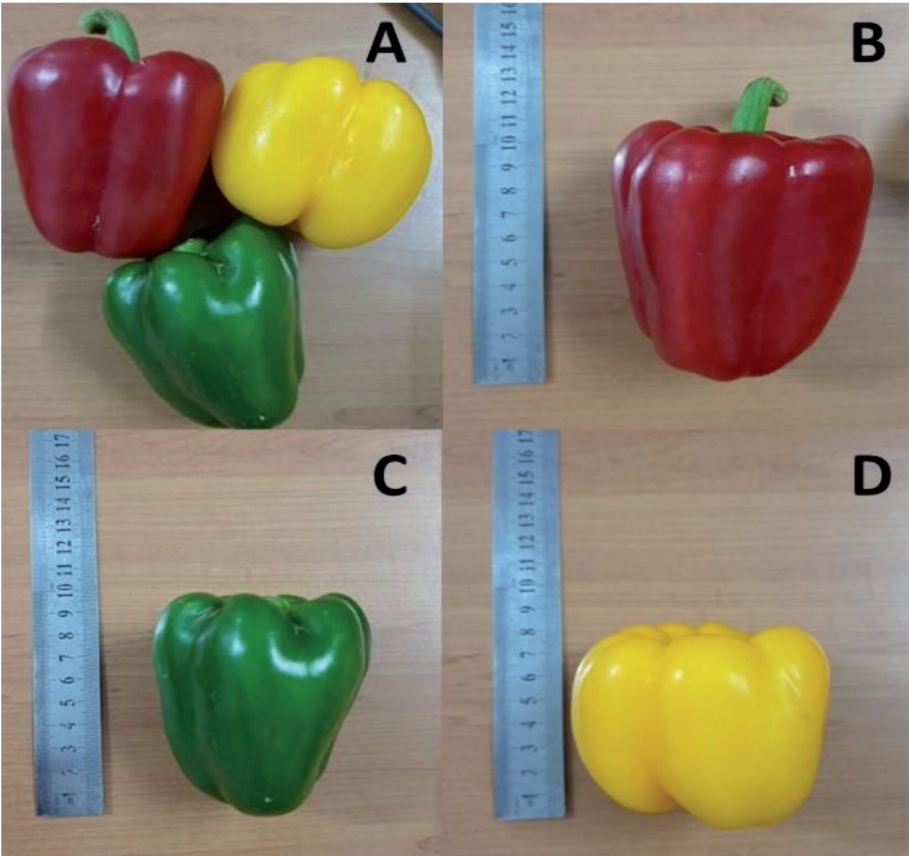


Figure 4. (A) Some paprikas commonly available in Indonesian market, (B) red paprika (C) green paprika, (D) yellow paprika.

an alternative intervention for Alzheimer's disease (AD) by inhibiting β -secretase activity and β -Amyloid₁₋₄₀ aggregation [38]. It is stated that phenolic extracts from the fruits could counteract the initial aggregation of A β ₁₋₄₀, as well as prevent further aggregation of preformed fibrils. The deposition of amyloid protein as senile plaques produced by the sequential cleavage of the amyloid precursor protein by secretases was the key signature of Alzheimer's disease. These inhibitory activities were attributed to the presence of phenolic constituents in the fruits [38].

2.1.4 *Cabai rawit* (*Capsicum frutescens*)

As it is shown in **Figure 5**, *cabe rawit* fruits are small, around 3.7–5.3 cm long, and the seeds are usually light brownish [12]. On average, each plant can produce a 0.5–0.6 kg fruit/harvesting period [18]. There are several cultivars of *cabai rawit* in Indonesia. A bit bulky with round tips is *cabai ceplik*. Immature *cabai ceplik* in Indonesia turned color from bright green to dark red during maturation. *Cabai rawit* with relatively higher pungency than *cabai ceplik* is *cabai jemprit*. The fruit is small and short and has a sharp point. The fruit turns color from dark green to red during maturation. *Cabai putih/cabai rawit domba* looks similar to *cabai jemprit*, but the color is yellowish and turns bright reddish orange during maturation [24]. There are also other cultivars called *cabai kathur* because the fruit's tip points to the sky and *cabai burung* or bird eye pepper with small fruits. There are several seed varieties cultivated in Indonesia, e.g., Pelita 8, Sonar, Bara, Taruna, Dewata, Nirmala, Lentera, Raga, Bhaskara, Maruti, Cakra Putih, and Cakra Hijau.

Distribution areas. *Cabai rawit* is cultivated in almost every province in Indonesia, especially in West Java, Central Java, East Java, Aceh, West Nusa Tenggara, and Bali [25].

Flavor characteristics. The taste of *cabai keriting* is relatively hotter than *cabai merah besar* (*C. annuum*) but not as hot as *cabai rawit* (*C. frutescens*). There were several varieties of *cabai rawit* in Indonesia, e.g., *rawit putih*, *cabai rawit hijau*, *cabai rawit Lampung*, and *cabai rawit Kalimantan*, according to the order of their pungency from low to high with 82,500–480,000 SHU [19], the major organic acids of *C. frutescens* were malic, citric, and ascorbic acid. In contrast to *C. annuum* in which citric acid was the primary organic acid, in *C. frutescens*, the dominant organic acid



Figure 5.
Cabai rawit (*C. frutescens*).

was malic acid [26]. The volatile compounds of *C. frutescens* consisted of aliphatic esters and methyl salicylate imparting fruity and fresh impressions. However, as the fruit turned to red, the flavor changed towards more pungent and citrus-like aroma. The pungency also increased as the fruit matured [39], but the pungent compound might decrease at later stages of maturation [40]. The immature fruit, having less pungency than the mature ones, is used to be consumed raw with vegetable fritter snack, fried tofu, and tempeh or put into rissoles.

Nutrition components. *Cabai rawit* contains energy (103 kcal), protein (4.7 g), fat (2.4 g), carbohydrate (19.9 g), fiber (1.6 g), ash (0.5 g), calcium (45.0 mg), phosphorus (85 mg), vitamin A (11,050 IU), and vitamin C (70 mg) per 100 g fruits [24].

Bioactivity and health benefits. *Cabai rawit* contains phytochemicals such as flavonoids, capsaicinoids, and other phenolic compounds [41]. Capsaicinoids have been reported to have various health benefits such as antioxidant, anticarcinogenic, anti-inflammatory, and relieving neuropathic pain [42–45]. The locals believe that *cabai rawit* is good for the eyes, can cure cancer, alleviate joint pain, improve blood circulation, and stimulate appetite [46]. The potency of *C. frutescens* extract for anti-obesity in 3 T3-L1 cells, due to its higher content of phenolic compounds and antioxidant activity compared to *C. annuum*, was explored [39].

2.2 Exotic Capsicum

2.2.1 Cabai gendot (*Capsicum pubescens*)

Before 1916, this *Capsicum* was introduced to Indonesia, and the locals called this *cabai* as “cabai gendot,” “cabai bendot,” “cabai gondol,” “cabai gombol,” “cabai Bandung,” or “cabai Dieng” [47]. The fruit shape varies from round to globular, 3.5–4 cm long, and 2.5–4 cm in diameter with thick flesh [40]. The fruit color changes from green (immature) to red (mature). The seeds are relatively small and few. Some people might confuse this *cabai* as *C. chinense*. The picture of *cabai gendot* can be seen in **Figure 6**.

Distribution areas. *Cabai bendot* is usually cultivated in Bandung (West Java), Dieng (Central Java), Kota Batu, and Pasuruan (East Java). This *cabai* is rarely found in the market [16, 47].

Flavor characteristics. The flavor of *cabai gendot* differs from *C. annuum*. This *Capsicum* cultivar is relatively juicier and hotter than *cabai merah besar*, around 100,000–350,000 SHU. The fruit has a fruity and floral aroma [34]. Due to their hotness, some people rarely eat fruit raw. People used to put both mature and immature stages of *cabai gendot* in *sambal* and mix them in stir-fry vegetables (*oseng-oseng*), or other plant-based dishes (e.g., *sayur tahu*, *sayur asem*). The fruits also have a strong and unique pungent aroma [47].



Figure 6.
Cabai gendot (*C. pubescens*) (A) red *cabai gendot* (B) green *cabai gendot*.

2.2.2 *Cabai katokkon* or *cabai kotokkon* (*C. chinense*) or (*Capsicum annuum* L. var. *sinensis*)

The name *cabai katokkon* was derived from the word “katokkon,” which means “big fruit.” This *cabai* is classified as *C. chinense* [1] or *C. annuum* L. [48]. The fruits are shaped like paprika but smaller (around 3–4 cm in length and 2–3.5 cm in diameter), round, and bulky as shown in **Figure 7**. The immature fruit is purplish green and turned bright red when mature. This plant can grow well on 200 m above sea level with adequate sunlight and watering. The plant can be harvested 3 months after seed planting, and on average, the plant can produce 0.8–1.2 kg fruits/harvesting period, i.e., 8–10 months [49].

Distribution areas. *Cabai katokkon* is cultivated in Rantepao, Tana Toraja (South Sulawesi) [1].

Flavor characteristics. The fruits have a unique floral, fruity and strong pungent aroma, and higher pungency than commonly consumed *Capsicums* [1]. By calculating the concentration of capsaicin (without taking account of dihydro-capsaicin), the pungency level of cabai kotokkon dried powders was reported to be around 42.914 SHU (immature stage) and 48.778 SHU (mature stage) [50]. Other sources reported the pungency level of 400,000–691,000 SHU [48].

Bioactivity and health benefits. Besides containing vitamin C and provitamin A that have antioxidant capacity, in Tana Toraja, South Sulawesi, people believe that the fruits could increase appetite, prevent aging, reduce stress, help to alleviate joint pains, lower cholesterol, improve blood circulation, prevent stroke, and alleviate wet cough, nasal congestion, and migraine [49].

2.2.3 *Cabai domba* (*Capsicum frutescens*)

The fruit shape is small but a little bit bigger than common *cabai rawit*. It has a round tip as shown in **Figure 8**. The color of the fruit varies from greenish white (immature stage), pale green, and orange [51]. Some people put them in the same category as *cabai rawit*; thus, it is called “cabai rawit domba” or “cabai putih,” and some other people confused cabai domba as *Capsicum annuum* L. var. *abbreviata* Fingerhuth.

Distribution areas. *Cabai domba* is cultivated in Bandung, West Java [51].

Flavor characteristics. The pungency of the fruit is around 50,000–100,000 SHU [49]. Due to their relatively hot taste, the fruit is rarely consumed raw; instead,



Figure 7.
Cabai katokkon (*C. chinense*) growth in the garden.



Figure 8.
Cabai domba (*C. frutescens*).



Figure 9.
Cabai hiyung (*C. frutescens*) [54].

people mixed it in their cooking or put in *sambal*. They have a strong pungent smell, especially when exposed to heat.

2.2.4 *Cabai hiyung* (*Capsicum frutescens* L.)

Cabai hiyung has an appearance similar to *cabai rawit*, around 2–3 cm in length, and relatively thin skin with the weight of each fruit is around 0.7 g [52]. The plant can be harvested at the age of around 3–4 months with harvesting period of 6–7 months. The fruits are harvested when they turn brownish yellow or red [53]. The picture of *cabai hiyung* [54] can be seen in **Figure 9**.

Distribution areas. *Cabai hiyung* is cultivated in Hiyung village, South Kalimantan [53].

Flavor characteristics. The fruit was reported as having many times higher pungency than the common cultivar of *C. frutescens* in Indonesia; therefore it was named as the hottest *C. frutescens* in Indonesia [55]. Though we could not find the level of pungency in SHU, the fruits reported having 802 ppm of capsaicin [56].

Nutrition components. The fruit was reported containing vitamin A (11.89 IU/100 g), 82–92 mg/100 g vitamin C, and 1.2–1.5% protein [53, 56].

2.2.5 *Cabai ceremai* (*Capsicum chinense*)

This *cabai* is a habanero-type pepper (*C. chinense*), in which the colors vary from green, yellow, bright orange, and orange. Different names have been attributed to this

fruit, such as “cabai ceremai,” “cabai cermi,” “cabai kancing,” “cabai tomat,” “cabai belimbing,” “baby chili Haba,” and “cabai tawau.” The fruits are generally clustered into three to five pieces in each branch. The fruit shape varies from round shape with a papillae tip to bell and cone and long shape with fruit length up to 12 cm. The fruit skin wrinkles, but sometimes it also has smooth skin. The colors of the fruits vary from green, red, orange, pink, yellow, or brown. The seeds have a pale color [1, 4].

Distribution areas. The distribution of *cabai ceremai* in Southeast and East Asia was still limited. *Cabai ceremai* can be found in Jakarta, Bogor, Sukabumi (West Java), Jepara, Tawangmangu (Central Java), Malang (East Java), Bangka Island, Bali, Putu Sibau (West Kalimantan), and Tarakan (East Kalimantan) [1, 4].

Flavor characteristics. The fruit was reported to have high pungency [1, 4], but we could not find the data on the level of pungency in SHU. *Cabai ceremai* was not popular in the market since consumers preferred to buy and consume *cabai* that have elongated shape [57].

3. *Cabai* utilization and applied products in Indonesia

Since its first coming to Indonesia, *cabai* has been widely utilized in the food and culinary industry. Besides that, *cabai* in Indonesia was also utilized in the pharmacy as transdermal medicine (plaster, oil, balm, and cream) and as ornamental plants due to its attractive and unique fruit colors.

3.1 *Cabai* in Indonesia food and culinary culture industry

Cabai is considered as an important ingredient since it is inseparable from Indonesian food culture as is shown in some of Indonesia dishes in **Figure 10**. During a meal, if *cabai* is not included in the dish seasoning, it will be served separately as “*sambal*,” crushed *cabai* mixed with various other ingredients and commonly eaten alongside the main course, or the *cabai* will be served to be eaten raw. Some people even consider something missing in their meal, and it would not be “complete” if their food is not spicy or there is no *sambal* to be eaten with the main course. Therefore, their satisfaction with the food will decrease. Over time, the way of people consuming *cabai* was developed, and *cabai* was transformed into processed food products, such as sauce and powder, as the complementary dish of the main course (**Figure 11**).

The utilization of *cabai* in local cuisines may vary from vegetable-based food such as stir-fry vegetables or as a sauce (or like salad dressings) together with peanut in mixed vegetables, such as *gado-gado*, *pecel*, and *karedok*. *Cabai* is also mixed in meat-, chicken-, and seafood-based cuisines, such as *rendang* (Indonesian famous pungent cuisine), *gulai* (spicy curry), *asam padeh* (spice and acid fish curry), and other dishes. “Balado” is an Indonesian dish that combines any type of food ingredients with *cabai merah*, for example, egg *balado*, fish *balado*, chicken *balado*, *dendeng* (dried meat) *balado*, eggplant *balado*, and shrimp *balado*.

3.1.1 *Sambal*: An Indonesian traditional crushed *cabai*

Sambal is an Indonesian famous and essential complementary cuisine made from *cabai* as the main ingredient. It is a crushed or grounded *cabai* with or without any other ingredients. Generally, *sambal* is known to stimulate appetite or to increase food palatability [8]. Before *Capsicum* came to Indonesia, *sambal* was originally made from ginger. Then people started to prepare *sambal* from pepper (*merica*) and *cabai Jawa* (*Piper retrofractum*) [58]. Since *Capsicum* spp. was introduced to Indonesia and cultivated, *sambal* was dominantly made from *Capsicum* spp.

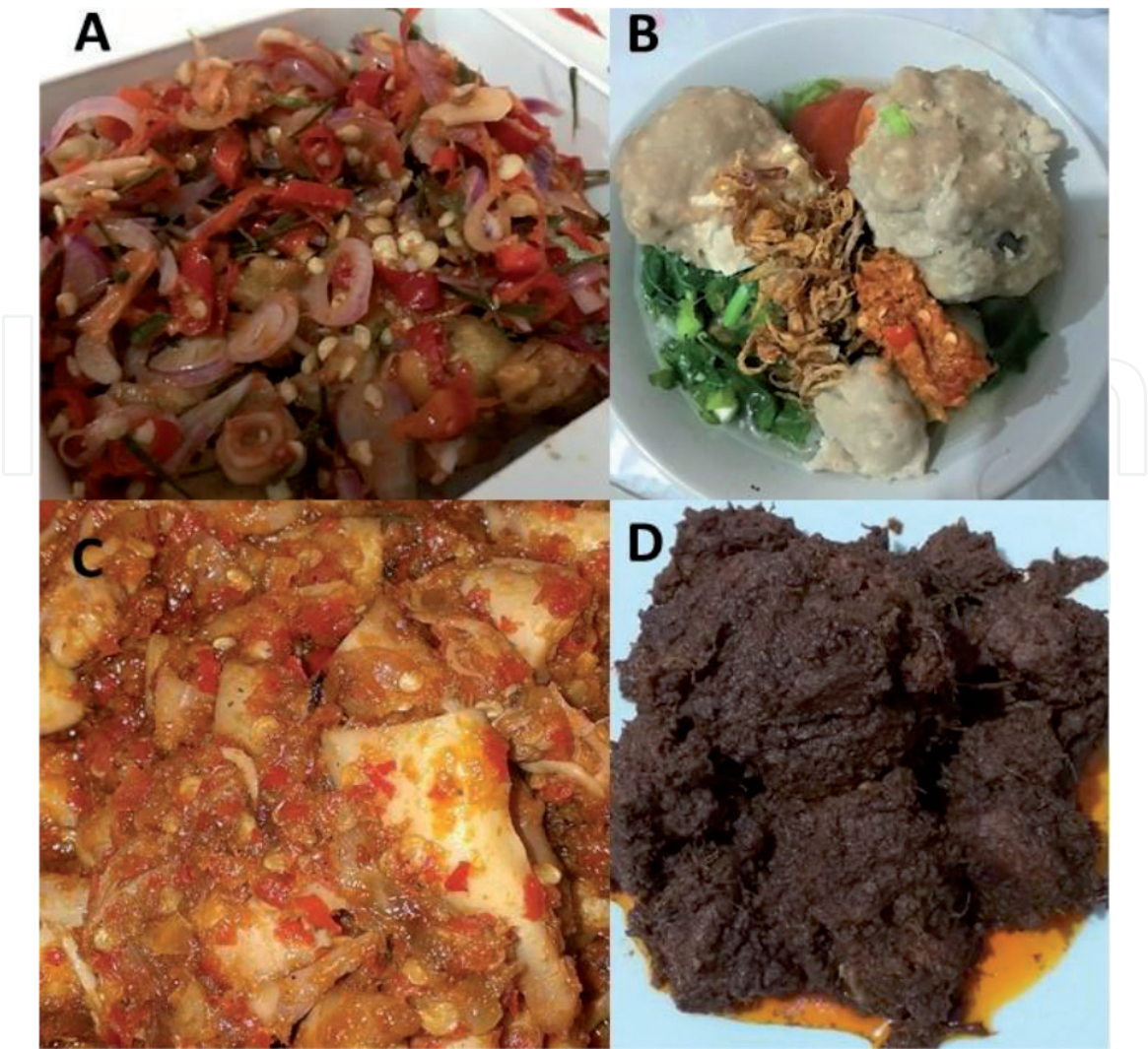


Figure 10.
Cabai as an inseparable ingredient in Indonesian cuisines. (A) Cabai slices are mixed as ingredient in daily cuisine, (B) Sambal and cabai sauce in meat balls cuisine, (C) Cumi balado (calamari balado) as an example of balado dish, (D) Rendang, Indonesian famous spicy cuisine with cabai as one of essential ingredient.

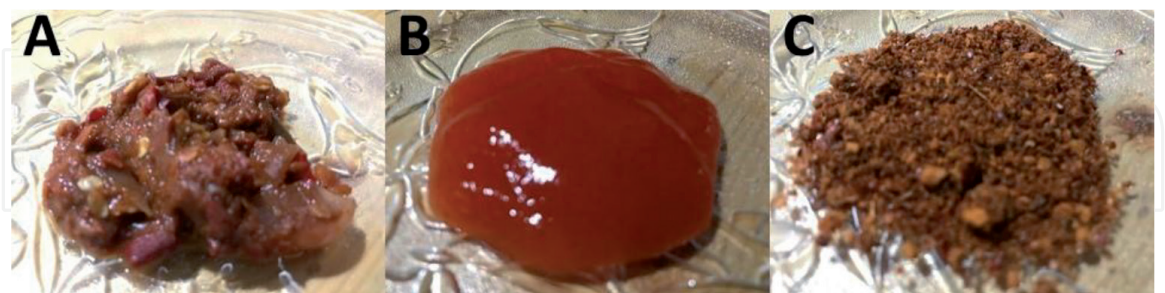


Figure 11.
Common cabai processing product in Indonesia. (A) Sambal terasi, (B) cabai sauce, (C) cabai powder.

Almost every region in Indonesia has their own types of *sambal*. There were about 322 types of *sambal* in Indonesia, and they varied over the nation with 119 types of raw *sambal*, 138 types of cooked *sambal*, and other types of *sambal* [59]. *Sambal terasi*, as seen in **Figure 11(A)**, was made from *cabai merah*, *cabai rawit*, *terasi* (fermented shrimp), onion, garlic, salt, and sometimes tomato. *Sambal roa* from Manado, North Sulawesi, was made from *Capsicum* and smoked *roa* fish, which can be found abundantly in some particular areas. *Sambal tempoyak* from southern Sumatra was mainly made from *Capsicum* and *tempoyak*, a fermented durian. Other examples of *sambal* variants are mango *sambal*, *andaliman sambal*, *matah sambal*, various kinds of fish

and seafood *sambal*, and sweet soy sauce *sambal*. The local culture and commodities available in the area influenced the ingredients included in *sambal*.

3.1.2 Cabai sauce

Cabai sauce or “saus cabai,” as seen in **Figure 11(B)**, is described as a sauce made from *Capsicum* sp. as the main ingredient and processed with or without the addition of other legitimate food additives [60]. *Saus cabai* is usually made from *cabai*, salt, onion, and garlic, with the addition of cornstarch as a thickening and binding agent [61]. The ingredients are sorted and washed, and then, *cabai* is steamed, mixed, and grounded with other ingredients. Cornstarch solution is added, and the mixture is cooked. Acidity regulators and preservative agents are added and mixed before *saus cabai* are packed and stored [61]. The flavor of *saus cabai* varies from sweet to spicy, but its pungency level is usually lower than *sambal*.

3.1.3 Cabai powder

Cabai powder, as seen in **Figure 11(C)**, is used as an ingredient to bring up spicy taste in savory processed food such as instant soup, instant noodles, and snacks. In 2012, a company developed a mixture of *cabai* powder with other ingredients such as onion, garlic, pepper, and also with particular fish and shrimp. The addition of fish and shrimp has enriched the umami taste of *cabai* powder products in Indonesia. “Tasty chili powder” with umami and spicy taste is developed as an innovation of *cabai* powder, and a new habit of eating *cabai* emerged in Indonesia with this dry powder as a condiment to be sprinkled on top of the food instead of dipping or mixing the food in *sambal*. The spiciness of tasty chili powder varies up to several levels from low to high. In the making of this powder, the ingredients were sorted, blanched, dried, grounded, and packed [61]. Tasty chili powder contained up to 16.8 ppm capsaicin [62].

3.2 Other rare and unique foods from *Capsicum* in Indonesia

3.2.1 Manisan cabai/sweetened capsicum

Manisan cabai is sugar-sweetened *Capsicum* slices, which is commonly eaten as a snack. It is usually made from thick-skinned red *Capsicums* such as *cabai merah besar* (*C. annuum* L.). The processing of sweetened *Capsicum* started from seed removal. The remaining skin is soaked in the salt solution to remove the pungent flavor. Then, *Capsicum* is soaked in CaCO_3 solution to harden the texture before being soaked in the warm sugar solution for 6–12 hours to absorb the sugar. The sweetened *Capsicum* may be dried and sprinkled with sugar. Then the resultant products are being packed and stored. Besides altering *Capsicum*’s taste by masking the pungency and increasing the sweetness, which makes *Capsicum* likable by children, this process also lengthens the shelf life of *Capsicum* due to high sugar concentration. The example of sweetened *Capsicum* is shown in **Figure 12**.

3.2.2 Capsicum chocolate bar

Capsicum chocolate bars tasted like typical chocolate bars at early bites, but the pungent taste of *Capsicum* will appear after several bites. Although *cabai rawit* (*C. frutescens*) used in the chocolate bar has quite strong pungency level, it can be covered by the high content of chocolate (58–60%) [63]. An example of *Capsicum* chocolate bar can be seen in **Figure 13**.



Figure 12.
Sugary sweetened Capsicum (Manisan cabai) .



Figure 13.
Capsicum chocolate bars.

3.2.3 *Kopi cabai rawit/Capsicum frutescens coffee*

Kopi cabai rawit is a mixture of coffee, milk, ginger, and *cabai rawit* (*C. frutescens*). This beverage can be found in Bandung, West Java, Indonesia. This coffee has a unique taste from the bitterness of caffeine, pungency from ginger, and spiciness from *cabai rawit*. After drinking the coffee, people felt a warmth sensation towards the throat and the body [64].

3.3 Pharmacy

Indonesia is rich in spices and herbs, and the locals have been utilizing them as traditional medicine for years. This tradition has been developed, as the active ingredients from traditional medicine are processed into more convenient products with the same function and characteristics. Plasters/patches, cream, balm, and oil with pungent and mint sensations have been used daily for muscle pain, headache, stomachache, and reducing the pain of toothache. The applications of those products from *Capsicum* are verily nurtured in Indonesian culture.

Capsaicin, responsible for pungent taste in *Capsicum*, also plays a role in the hot sensation in the skin. This hot sensation is utilized in the pharmacy industry as

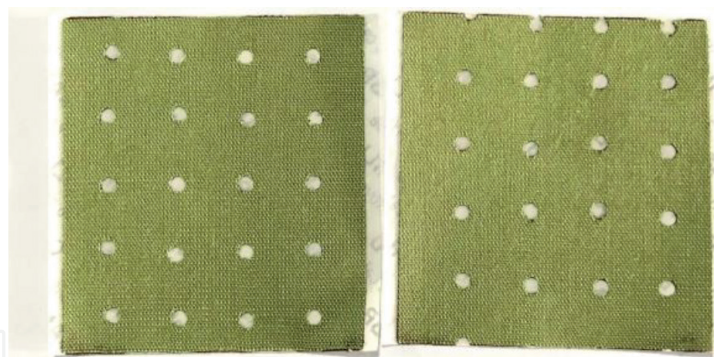


Figure 14.
Koyo cabai, the Capsicum hot medicated plaster in Indonesia.

a muscle pain reliever by adding plaster fabric, cream, or gel, together with other supporting ingredients. Besides that, capsaicin cream is useful for chronic soft tissue pain and chronic back pain. It gives beneficial effects as first-line therapy of osteoarthritis pain and decreases post-surgical neuropathic pain [65–67].

3.3.1 *Koyo cabai* or *capsicum* transdermal patch/*capsicum* hot medicated plaster

Koyo cabai or *Capsicum* Hot Medicated Plaster is one of medicated plasters in Indonesia. It is usually used for the treatment to relieve muscle pain or reduce the pain of toothache. *Koyo cabai*, at first imported from a Deutsch company, had been used in Indonesia since 1970. However, in 1983, a local company started to produce *koyo cabai* [68]. The plaster was made from high concentration *cabai* extract mixed with rubber as sticking agent and other ingredients. The sticky mixture then applied and pressed to the plaster fabric layer. The layer was cut and packed. *Koyo cabai* as a famous *Capsicum* Medicated Plaster in Indonesia can be seen in **Figure 14**. One Capsaicin Medicated Plaster may contain 0.37 mg/cm² of *Capsicum* extract [69].

3.3.2 *Cabai* cream and *cabai* balm

Similar to *koyo cabai*, *cabai* cream or *krim cabai* and *cabai* balm or *balsam cabai* in Indonesia are mainly utilized to relieve muscle pain and headache. It is a common thing that people in Indonesia keep muscle pain-relieving cream or balm as a first aid medicine in their homes or travel kits. *Cabai* cream may contain 1.66% *cabai* oleoresin; meanwhile, *cabai* balm may contain 0.56% *cabai* oleoresin.

3.4 Plant ornaments

Ideally, ornamental *cabai* has bonsai-like quality that is short in height (dwarf) and produces quite a number of fruits with various colors [70]. *Capsicum* species, especially *C. chinense* and *C. pubescens*, are attractive to be used as ornamental plants. *C. chinense* has various fruit shapes that look like a combination of tomato and starfruit and different bright colors during maturation, while *C. pubescens* has purplish fruits and is combined with erect flowers [71].

From the ornamental plants *C. annum* L., the variety is called “Ayesha IPB” [70]. The plant relatively early blossoms in 13–16 days after planting and can be harvested in 65–70 days after planting. The average plant height is 25 cm with 46–53 cm of canopy width, and the leaves of canopy are nicely clustered. The fruits have round tips, and they would turn from yellow green (immature stage) to orange (intermediate) and orange red (mature stage). The other variety is called

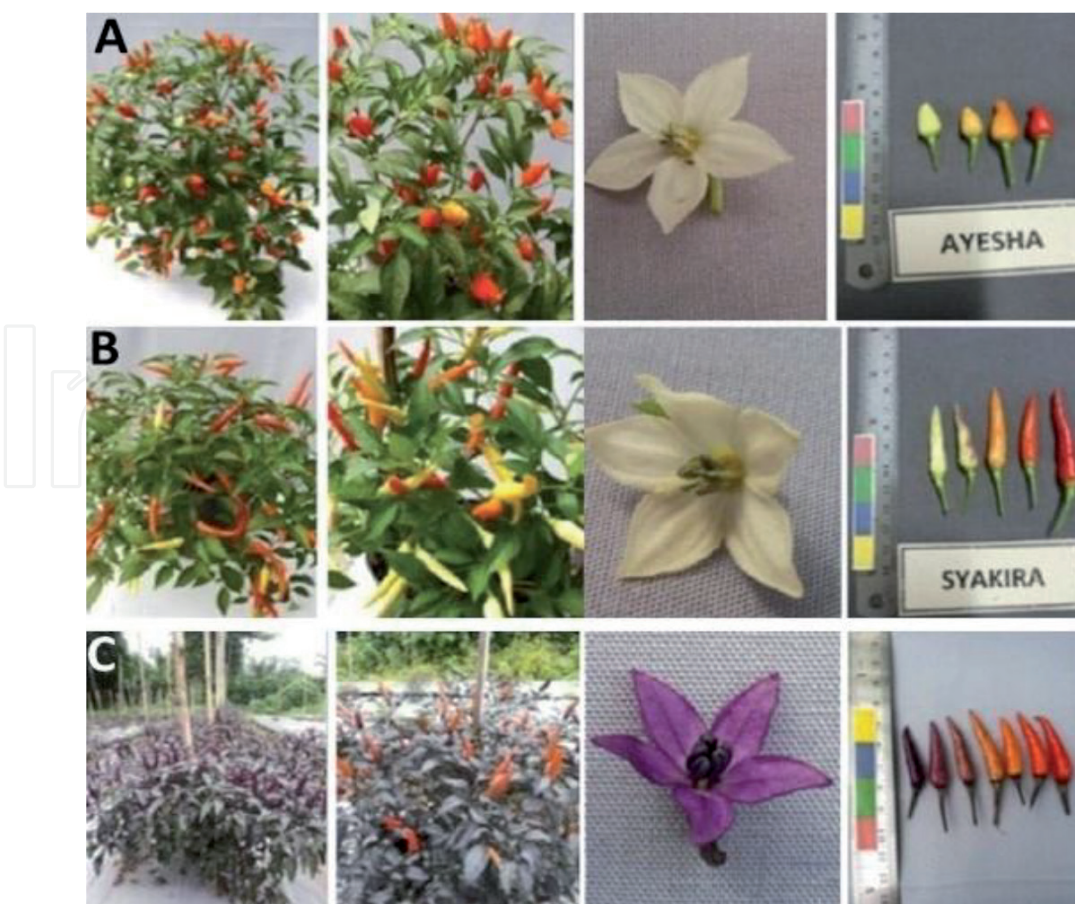


Figure 15.
Some *Capsicum* ornamental plants in Indonesia (A) Cabai Ayesha (B) Cabai Syakira (C) Cabai Lembayung [73].

“Lembayung IPB” with a short height, purplish stem and stalk, and attractive fruit colors. The immature fruit color is purple and they would turn into dark orange [72]. The fruit tastes relatively hot. Other ornamental cultivars from *C. annuum* are “Namira,” “Syakira,” “Jelita,” and “Ungara.” Some types of *cabai* as ornamental plants [73] can be seen in **Figure 15**. Colorful *Capsicum* as ornamental plant is famous to be called as *cabai pelangi* or *rainbow cabai* in Indonesia.

4. Conclusion

The major *Capsicum* species commercially important in Indonesia are *C. annuum* and *C. frutescens*. Cultivars from *C. chinense* and *C. pubescens* were rarely found in the market and can be considered exotic and mostly cultivated for ornaments. *Capsicum* is profoundly intertwined and inseparable from Indonesian culture, from food and pharmaceuticals to ornaments with many variations of the products. The market is still exceptionally receptive to innovations to transform and include *Capsicums* in the products. The variety of *Capsicums* in Indonesia and the potential applications combined with prospective market also make the field of flavor and bioactive compounds of *Capsicums* in Indonesia attractive to be investigated.

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Conflict of interest

The authors declare no conflict of interest.

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